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About the Cover

Fourth launch of the Space Shuttle Columbia June 27 from NASA's Kennedy Space Center, Fla. Completing 7 days in space, Columbia travelled 3 million miles to land back on Earth on the nation's 206th birthday to complete the spacecraft's fourth and final test flight. The first operational Space Shuttle mission is scheduled for launch no earlier than November 11 and will carry a crew of four: Vance D. Brand, commander; Robert F. Overmyer, pilot; Joseph P. Allen and William B. Lenoir, mission specialists. Below are scenes from the Mission Operations Control Room at Johnson Space Center, Houston. Top frame shows the control center monitoring the Shuttle during flight day two of the mission (screen at back left); bottom frame was taken the day of landing. Entry flight director Harold Draughan (foreground) views the flawless landing (second screen from back right).

Contents

Space Shuttle Mission 4—Pictorial Highlights	3
Remarks by the President, July 4, 1982	13
National Space Policy	15
Administrator's Column	18
Why the United States Needs a Space Station	21
Four Moons of Uranus Measured for the First Time	26
Pioneers May Find Tenth Planet, Dark Star or Black Hole	26
"Slippery" Wings Smooth Way for Business Plane Fuel Savings	28
Booster Hardware Set for Reuse on STS-5	30
Finalists Chosen in Second Shuttle Student Involvement Project	31
Patents for Inventions	35
Space Shuttle Launches for 1982	35
Expendable Launches for 1982	35
Another Dividend from Air and Space	36

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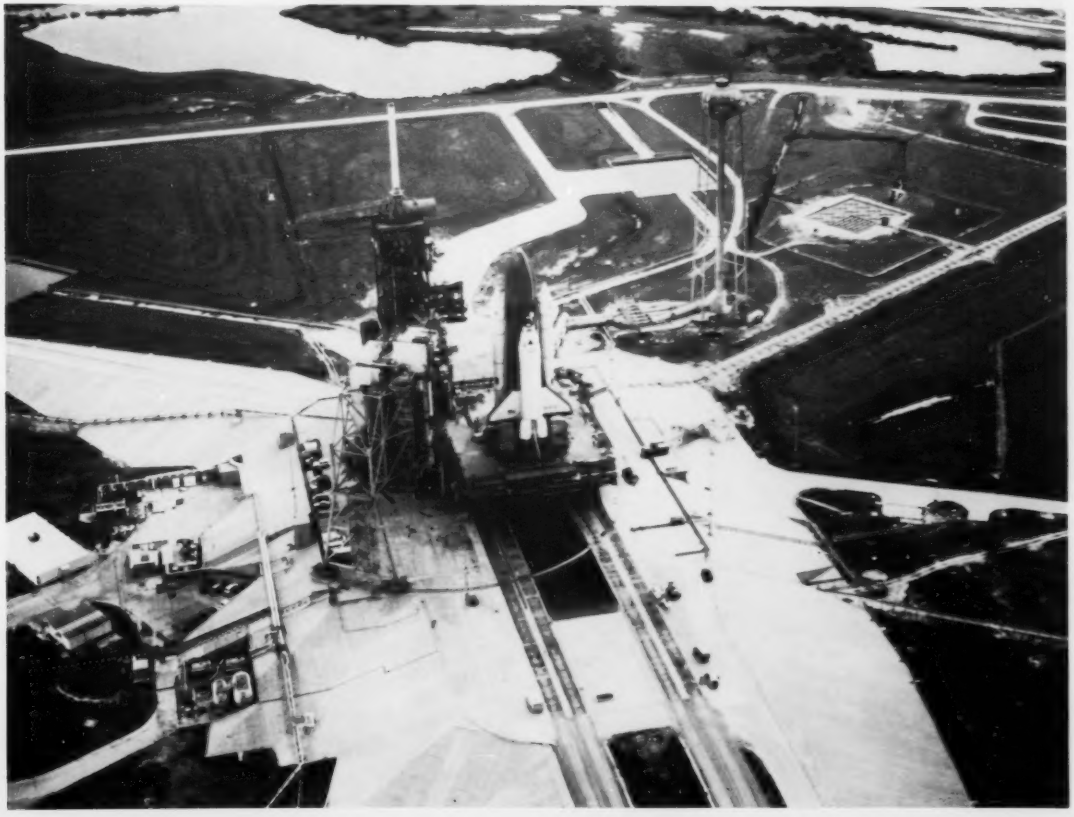
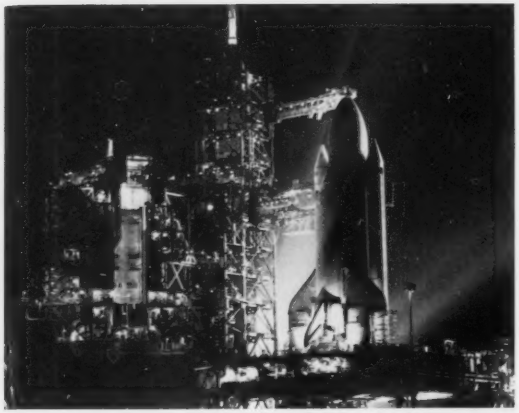
Space Shuttle Mission 4—Pictorial Highlights

Crew	Thomas K. Mattingly, commander Henry W. Hartsfield, pilot
Rollover to Vehicle Assembly Building	May 19
Time in Orbiter Processing Facility	40 working days (shortest time to date)
Rollout	May 26
Launch	June 27
Launch time	11 a.m. EDT
Launch site	Kennedy Space Center, Fla. Pad 39A
Landing	July 4
Landing time	12:09:40 EDT
Mission duration	7 days, 1 hour, 11 minutes, 11 seconds
Orbits	112 full orbits, deorbit burn for reentry on 113th orbit

Fourth rollout of the Space Shuttle Columbia to Kennedy Space Center's launch pad 39A. The spacecraft's 3.5 mile journey from the Vehicle Assembly Building to the pad took approximately six hours to complete aboard the giant crawler transporter.





Shuttle 4 commander T. K. Mattingly (right) and pilot Henry Hartsfield at Kennedy Space Center's Shuttle Landing Facility after flying simulated landing approaches in the NASA gulfstream jets. These aircraft are modified to produce flight characteristics similar to the Space Shuttle. **(top left)**

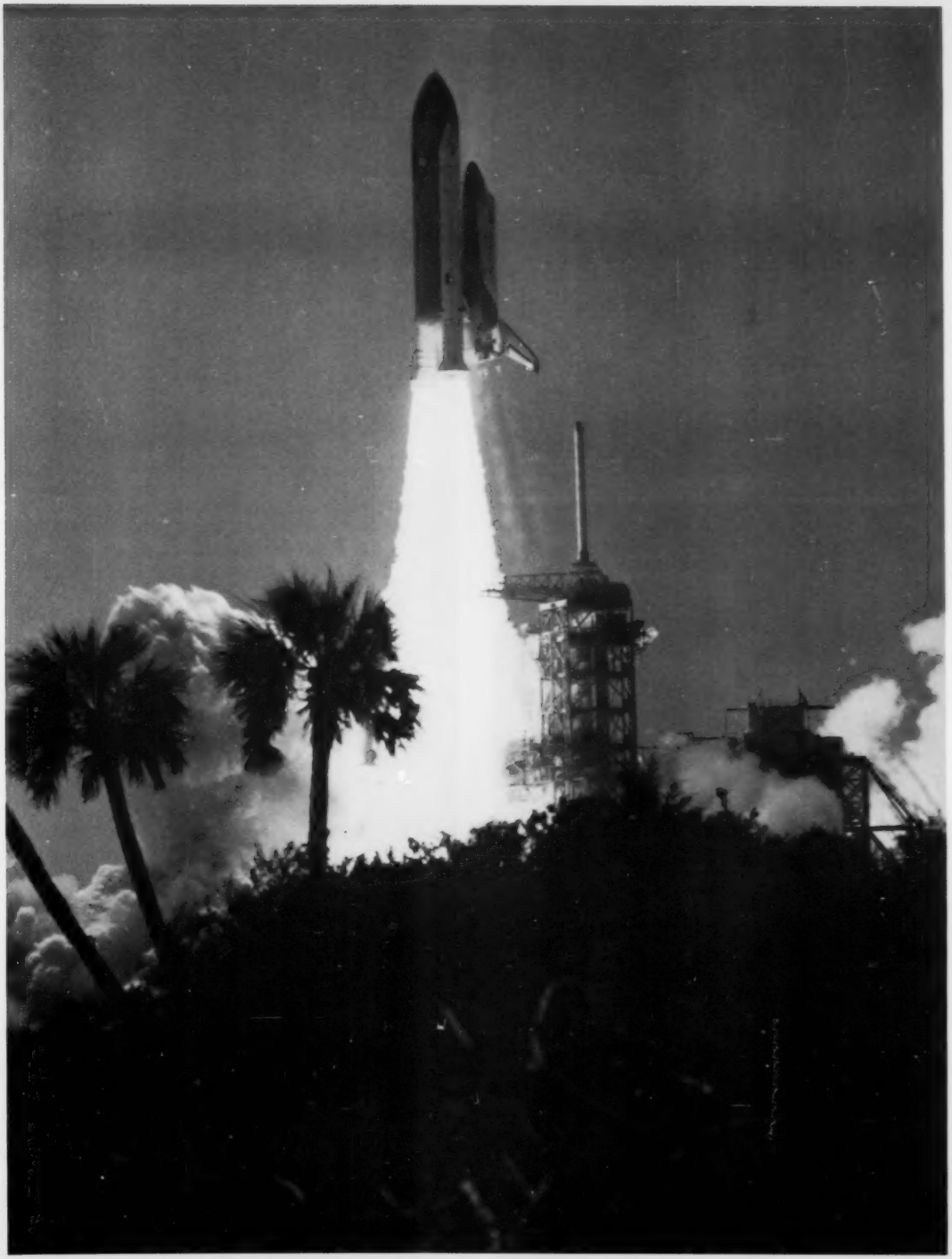
Fourth Shuttle prime crew at their pre-launch breakfast. Nancy Gunter, manager of the Kennedy Space Center astronaut office, provided the cake decorated with the colors and design of the mission patch. **(center left)**

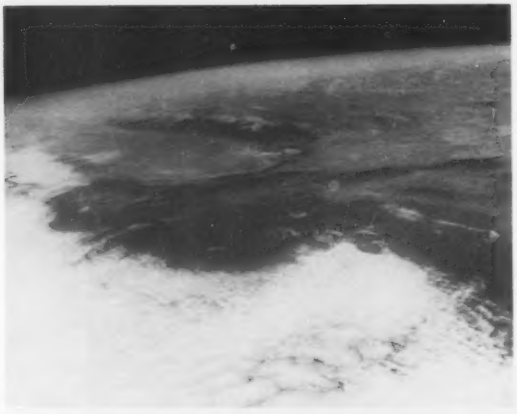
Mattingly and Hartsfield suit up for their 7-day mission the morning of June 27. **(bottom left)**

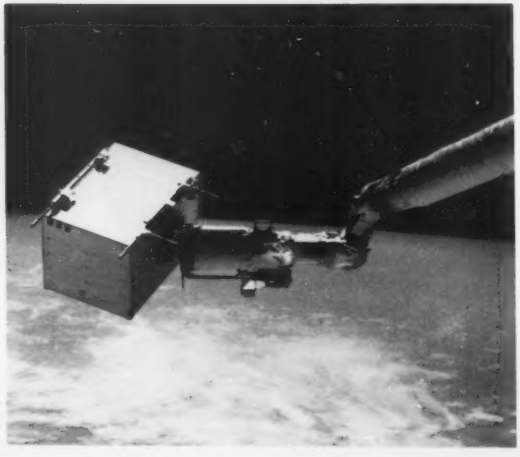
Shuttle mission 4 astronauts enter the launch pad "white room" where they complete flight preparations and enter the cockpit of Columbia. **(top right)**

Skyward streaming light silhouettes Columbia in the early morning hours on launch day, June 27. **(bottom right)**

Fourth launch of Space Shuttle Columbia, June 27. Liftoff time was 11 a.m. EDT. **(page 5)**







Photography from Columbia:

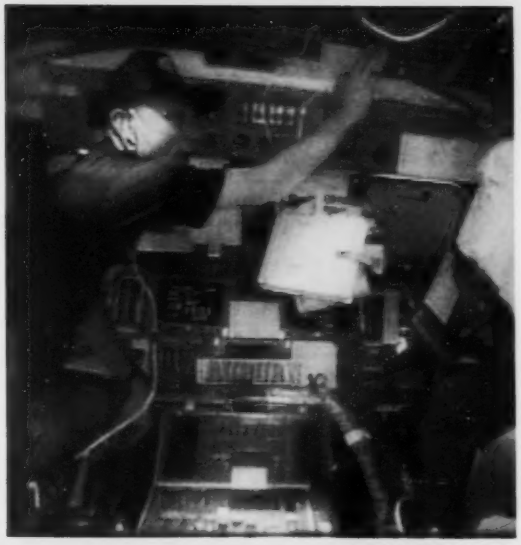
Baja California, Norte and Sonora states with sunlight on the Sea of Cortez (Gulf of California). Above and to the right of center are islands of Angel de la Guardia and Tiberon. **(top left)**

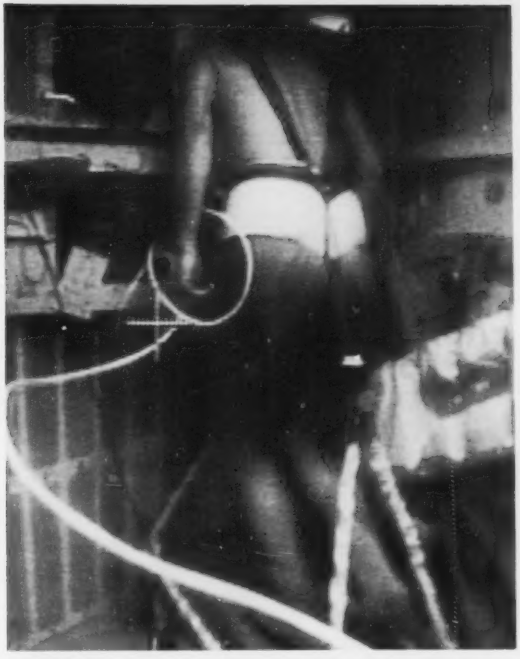
Northeastern view of California's Pacific Coast taken by a handheld 70-mm camera aimed through Columbia's windows. **(center left)**

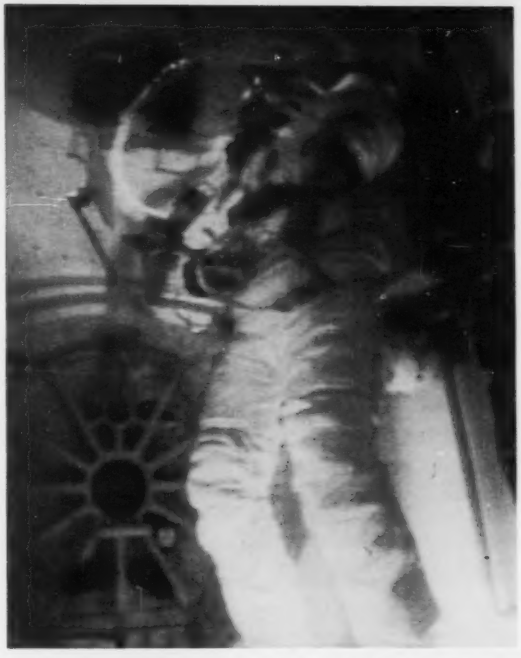
Silhouetted against the black of space, Columbia's Remote Manipulator System deploys the Induced Environment Contamination Monitor, a device to check for contaminants in and around the orbiter cargo bay. **(bottom left)**

Handheld camera scene of both Florida coasts. Cape Canaveral is located at center of the frame. This photo was taken through an aft window on the flight deck of Columbia. The spacecraft's vertical tail and orbital maneuvering system pods are in foreground **(top right)**

Space Shuttle TV: Flight day 4. Mattingly in the mid-deck section of the orbiter about to toss a plastic food container he is holding to illustrate a point about force in micro-gravity. **(bottom right)**







More Shuttle TV: Pilot Henry Hartsfield on flight day 4 gives an "open house" tour of the orbiter. He has wedged his socked feet beneath the Continuqus Flow Electrophoresis System experiment located in the spacecraft's mid-deck. **(top left)**

On flight day 5, Hartsfield using the treadmill exercise device also located in Columbia's mid-deck. **(bottom left)**

T.K. continues the tour of the spacecraft on flight day 5, this view from the cockpit. A bumper sticker from the crew's alma mater, Auburn, is at lower center. **(top right)**

Flight Day 6, commander Mattingly undergoes suiting up exercise in the mid-deck area of Columbia. Suit worn by Mattingly is the EMU (extravehicular mobility unit), to be used on the next flight for EVA chores. **(bottom left)**

Commander Mattingly demonstrates meal preparation, using scissors to open a drink container. Various packages of food and meal accessories are attached to the locker door. **(top left)**

Hartsfield demonstrates the sleeping accommodations aboard Columbia. The sleep restraint is located in the mid-deck section of the orbiter. **(top right)**

Wide angle view of Johnson Space Center's Mission Operations Control Room during the final minutes of the launch countdown June 27. **(center)**

Fourth Shuttle mission lead flight director Chuck Lewis is congratulated following the successful landing of Columbia on July 4. **(bottom left)**

Cars and people as far as the eye can see on hand to witness the fourth landing of Columbia on July 4 at Edwards Air Force Base, Calif. The crowd numbered an estimated half a million people. **(pg. 9)**

Columbia makes its final approach for landing at Edwards Air Force Base, Calif., on July 4 accompanied by T-38 chase planes (one is located at top right of orbiter). Back wheels seconds from touchdown **(bottom photo)** on concrete runway 17 at Edwards—Columbia's first landing on a hard surface runway; for the previous three missions, the spacecraft touched down on dry lakebeds.

Mattingly and Hartsfield are all smiles when they exit columbia after a flawless touchdown on July 4. **(top left)**

Fourth Shuttle mission prime crew are greeted by very special guests at touchdown: the President and Mrs. Reagan. **(top right)**

Mission 4 prime crew and the nation's commander-in-chief exchange salutes; the President and the astronauts spoke before a crowd of thousands at a special July 4 ceremony highlighted by the landing of Columbia and the takeoff of the newest orbiter Challenger aboard NASA Shuttle Carrier Aircraft bound for Kennedy Space Center, Fla. **(bottom)**

NASA
Enterprise
United States

Special landing day ceremony was the order at Edwards upon the historic touchdown of Columbia on the nation's 206th Independence Day. Three orbiters provided visual testimony of the progress and success of the U.S. space program: the orbiter Enterprise, used for approach and landing tests; Columbia; and NASA's newest orbiter, Challenger, given a signal by President Reagan during the ceremony to lift off aboard the Shuttle Carrier Aircraft for Kennedy Space Center **(page 12, top)** where it will undergo processing prior to its first launch in January 1983. On the speakers platform **(bottom, page 12)** flanked by the Enterprise, are left to right: pilot Hartsfield, President Reagan, commander Mattingly, NASA Administrator James M. Beggs (at podium) and Nancy Reagan. Perfect dead center landing for Columbia on concrete runway 17 at Edwards Air Force Base, Calif., **(top photo)** on July 4, proved the spacecraft's ability to make a precision landing.

Remarks by the President

Fourth Landing of the Space Shuttle Columbia

Dryden Flight Research Facility
Edwards Air Force Base, Calif.
July 4, 1982

In the early days of our republic, Americans watched Yankee clippers glide across the many oceans of the world, manned by proud and energetic individuals, breaking records for time and distance, showing our flag and opening up new vistas of commerce and communications.

Well, today you've helped recreate the anticipation and excitement felt in home ports as the gallant ships were spotted on the horizon, heading in after a long voyage.

Today we celebrate the 206th anniversary of our independence. Throughout history we've never shrunk before a challenge. The quest for new frontiers for the betterment of our homes and families is a crucial part of our national character—something which you so ably represent today. The space program, in general, and the Shuttle program, in particular, have gone a long way to help our country recapture its spirit of vitality and confidence. The pioneer spirit still flourishes in America.

In the future, as in the past, our freedom, independence and national well-being will be tied to new acheivements, new discoveries and pushing back frontiers. The fourth landing of the Columbia is the historical equivalent to the driving of the golden spike which completed the first transcontinental railroad. It marks our entrance into a new era. The test flights are over, the groundwork has been laid,

now we will move forward to capitalize on the tremendous potential offered by the ultimate frontier of space.

Beginning with the next flight, the Columbia and her sister ships will be fully operational and ready to provide economical and routine access to space for scientific exploration, commercial ventures and for tasks related to the national security. Simultaneously, we must look aggressively to the future by demonstrating the potential of the Shuttle and establishing a more permanent presence in space.

We've only peered over the edge of our accomplishments; yet already the space program has improved the lives of every American. The aerospace industry provides meaningful employment to over a million of our citizens—many working directly on the space program, others using the knowledge developed in space programs to keep us the world leader in aviation.

In fact, technological innovations traced directly to the space program boost our standard of living and provide employment for our people in such diverse fields as communications, computers, health care, energy efficiency, consumer products and environmental protection. It's been estimated, for example, that information from satellites saves hundreds of millions of dollars per year in agriculture, shipping and fishing.

The Space Shuttle will open up even more impressive possibilities, permitting us to use the near weightlessness and near-perfect vacuum of space to produce special alloys, metals, glasses, crystals and biological materials impossible to manufacture on Earth.

Similarly, in the area of national security our space systems have opened unique opportunities for peace by providing advanced methods of verifying strategic arms control agreements.

The Shuttle we just saw land carried two kinds of payloads: one funded entirely by private industry and the other, related to our national security, sponsored by the Air Force. This versatility of the Columbia and her sister ships will serve the American people well. Yet we must never forget that the benefits we receive are due to our country's commitment, made a decade ago, to remain the world leader in space technology.

To insure that the American people keep reaping the benefits of space and to provide general direction for our future efforts, I recently approved a National Space Policy Statement—which is being released today.

Our goals for space are ambitious, yet achievable. They include:

- Continued space activity for economic and scientific benefits.
- Expanding private sector investment and involvement in space-related activities.
- Promoting international uses of space.
- Cooperating with other nations to maintain the freedom of space for all activities that enhance the security and welfare of mankind.
- Strengthening our own security by exploring new methods of using space as a means of maintaining the peace.

There are those who thought the closing of the western frontier marked an end to America's greatest period of vitality.

Yet, we are crossing new frontiers every day, the high technology now being developed, much of it a by-product of the space effort, offers us and future generations of Americans opportunities never dreamed of a few years ago. Today we celebrate American Independence confident that the limits of our freedom and prosperity have again been expanded by meeting the challenge of the frontier.

We also honor two pathfinders. They reaffirm to all of us that as long as there are frontiers to be explored and conquered, Americans will lead the way. They and the other astronauts have shown the world that Americans still have the know-how and Americans still have the true grit that tamed a savage wilderness.

Charles Lindbergh once said that "short-term survival may depend on the knowledge of nuclear physicists and the performance of supersonic aircraft, but long-term survival depends alone on the character of man."

National Space Policy
The White House
Office of the White House
Press Secretary

The President announced today [July 4, 1982] a national space policy that will set the direction of U.S. efforts in space for the next decade. The policy is the result of an interagency review requested by the President in August 1981. The ten-month review included a comprehensive analysis of all segments of the national space program. The primary objective of the review was to provide a workable policy framework for an aggressive, farsighted space program that is consistent with the Administration's national goals.

As a result, the President's Directive reaffirms the national commitment to the exploration and use of space in support of our national well-being, and establishes the basic goals of United States space policy which are to:

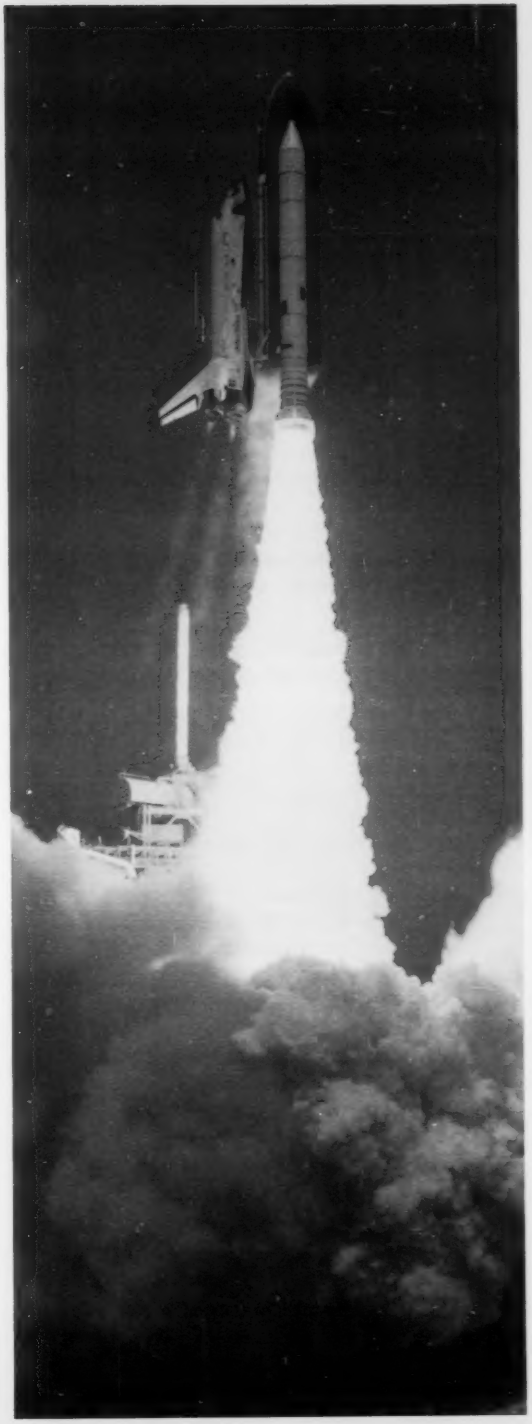
- strengthen the security of the United States;
- maintain United States space leadership;
- obtain economic and scientific benefits through the exploitation of space;
- expand United States private sector investment and involvement in civil space and space related activities;
- promote international cooperative activities in the national interest, and
- cooperate with other nations in maintaining the freedom of space for activities which enhance the security and welfare of mankind.

The principles underlying the conduct of the United States space program, as outlined in the Directive are:

- The United States is committed to the exploration and use of space by all nations for peaceful purposes and for the benefit of mankind. "Peaceful purposes" allow activities in pursuit of national security goals.

- The United States rejects any claims to sovereignty by any nation over space or over celestial bodies, or any portion thereof, and rejects any limitations on the fundamental right to acquire data from space.

- The United States considers the space systems of any nation to be national property with the right of passage through and operation in space without interference. Purposeful interference with space systems shall be viewed as an infringement upon sovereign rights.



- The United States encourages domestic commercial exploitation of space capabilities, technology, and systems for national economic benefit. These activities must be consistent with national security concerns, treaties and international agreements.

- The United States will conduct international cooperative space-related activities that achieve scientific, political, economic, or national security benefits for the nation.

- The United States space program will be comprised of two separate, distinct and strongly interacting programs—national security and civil. Close coordination, cooperation and information exchange will be maintained among these programs to avoid unnecessary duplication.

- The United States Space Transportation System (STS) is the primary space launch system for both national security and civil government missions. STS capabilities and capacities shall be developed to meet appropriate national needs and shall be available to authorized users—domestic and foreign, commercial and governmental.

- The United States will pursue activities in space in support of its right of self-defense.

- The United States will continue to study space arms control options. The United States will consider verifiable and equitable arms control measures that would ban or otherwise limit testing and deployment of specific weapons systems, should those measures be compatible with United States national security.

Space Transportation System

The Directive states that the Space Shuttle is to be a major factor in the future evolution of United States space programs, and that it will foster further cooperative roles between the national security and civil programs to insure efficient and effective use of national resources. The Space Transportation System (STS) is composed of the Space Shuttle, associated upper stages, and related facilities. The Directive establishes the following policies governing the development and operation of the Space Transportation System:

- The STS is a vital element of the United States space program, and is the primary space launch system for both United States national security and civil government missions. The STS will be afforded the degree of survivability and security protection required for a critical national space resource. The first priority of the STS program is to make the system fully operational and cost-effective in providing routine access to space.

- The United States is fully committed to maintaining world leadership in space transportation with a STS capacity sufficient to meet appropriate national needs. The STS program requires sustained commitments by each affected department or agency. The United States will continue to develop the STS through the National Aeronautics and Space Administration (NASA) in cooperation with the Department of Defense (DOD). Enhancement of STS operational capability, upper stages and methods of deploying and retrieving payloads should be pursued, as national requirements are defined.

- United States Government spacecraft should be designed to take advantage of the unique capabilities of the STS. The completion of transition to the Shuttle should occur as expeditiously as practical.

- NASA will assure the Shuttle's utility to the civil users. In coordination with NASA, the DOD will assure the Shuttle's utility to national defense and integrate national security missions into the Shuttle system. Launch priority will be provided for national security missions.

- Expendable launch vehicle operations shall be continued by the United States Government until the capabilities of the STS are sufficient to meet its needs and obligations. Unique national security considerations may dictate developing special purpose launch capabilities.

- For the near term, the STS will continue to be managed and operated in an institutional arrangement consistent with the current NASA/DOD Memoranda of Understanding. Responsibility will remain in NASA for operational control of the STS for civil missions and in the DOD for operational control of the STS for national security missions. Mission management is the responsibility of the mission agency. As the STS operations mature, the flexibility to transition to a different institutional structure will be maintained.

- Major changes to STS program capabilities will require Presidential approval.

The Civil Space Program

In accordance with the provisions of the National Aeronautics and Space Act, the Directive states that the civil space program shall be conducted:

- to expand knowledge of the Earth, its environment, the solar system and the universe;
- to develop and promote selected civil applications of space technology;
- to preserve the United States leadership in critical aspects of space science, applications and technology; and

- to further United States domestic and foreign policy objectives.

The Directive states the following policies which shall govern the conduct of the civil space program:

- United States Government programs shall continue a balanced strategy of research, development, operations, and exploration for science, applications and technology. The key objectives of these programs are to: (1) preserve the United States preeminence in critical space activities to enable continued exploitation and exploration of space; (2) conduct research and experimentation to expand understanding of: (a) astrophysical phenomena and the origin and evolution of the universe through long-lived astrophysical observation; (b) the Earth, its environment, its dynamic relation with the sun; (c) the origin and evolution of the solar system through solar, planetary, and lunar sciences and exploration; and (d) the space environment and technology to advance knowledge in the biological sciences; (3) continue to explore the requirements, operational concepts, and technology associated with permanent space facilities; (4) conduct appropriate research and experimentation in advanced technology and systems to provide a basis for future civil applications.

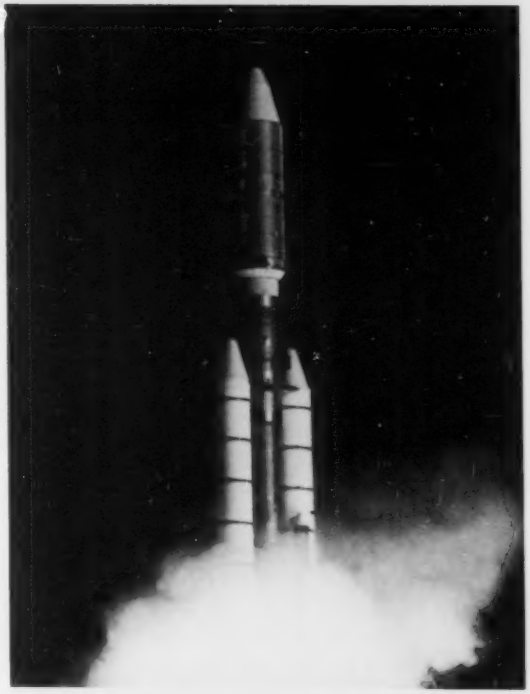
- The United States Government will provide a climate conducive to expanded private sector investment and involvement in space activities, with due regard to public safety and national security. These space activities will be authorized and supervised or regulated by the government to the extent required by treaty and national security.

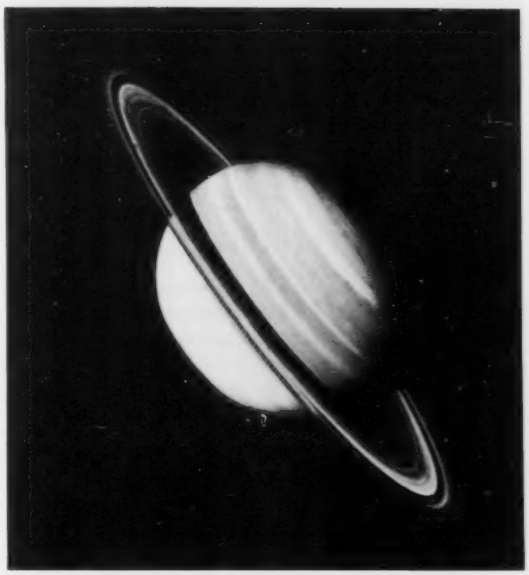
- The United States will continue cooperation with other nations in international space activities by conducting joint scientific and research programs, consistent with technology transfer policy, that yield sufficient benefits to the United States, and will support the public, nondiscriminatory direct readout of data from Federal civil systems to foreign ground stations and the provision of data to foreign users under specified conditions.

- The Department of Commerce, as manager of Federal operational space remote sensing systems, will: (1) aggregate Federal needs for these systems to be met by either the private sector or the Federal government; (2) identify needed research and development objectives for these systems; and (3) in coordination with other departments or agencies, provide regulation of private sector operation of these systems.

The National Security Space Program

The Directive states that the United States will conduct those activities in space that it deems necessary





Launch of the Voyager 2 spacecraft aboard a Titan/Centaur expendable vehicle on Sept. 5, 1977. Bottom photo shows one of the spacecraft's photos of Saturn, taken from a range of 27 million miles on July 12, 1981, one month, 11 days before the spacecraft's closest approach to the giant ringed planet.

to its national security. National security space programs shall support such functions as command and control, communications, navigation, environmental monitoring, warning, surveillance and space defense. The Directive states the following policies which shall govern the conduct of the national security program:

- Survivability and endurance of space systems, including all system elements, will be pursued commensurate with the planned use in crisis and conflict, with the threat, and with the availability of other assets to perform the mission. Deficiencies will be identified and eliminated, and an aggressive, long-term program will be undertaken to provide more assured survivability and endurance.
- The United States will proceed with development of an anti-satellite (ASAT) capability, with operational deployment as a goal. The primary purposes of a United States ASAT capability are to deter threats to space systems of the United States and its Allies and, within such limits imposed by international law, to deny any adversary the use of space-based systems that provide support to hostile military forces.
- The United States will develop and maintain an integrated attack warning, notification, verification, and contingency reaction capability which can effectively detect and react to threats to United States space systems.
- Security, including dissemination of data, shall be conducted in accordance with Executive Orders and applicable directives for protection of national security information and commensurate with both the missions performed and the security measures necessary to protect related space activities.

Inter-program Responsibilities

The Directive contains the following guidance applicable to and binding upon the United States national security and civil space programs:

- The national security and civil space programs will be closely coordinated and will emphasize technology sharing within necessary security constraints. Technology transfer issues will be resolved within the framework of directives, executive orders, and laws.
- Civil Earth-imaging from space will be permitted under controls when the requirements are justified and assessed in relation to civil benefits, national security, and foreign policy. These controls will be periodically reviewed to determine if the constraints should be revised.
- The United States Government will maintain and coordinate separate national security and civil operational space systems when differing needs of the programs dictate.

Administrator's Column

(Each month in this column *NASA Activities* will feature an article by NASA Administrator James M. Beggs. These articles will focus on subjects chosen by him to address topics of broad interest to the agency's employees.)

1990: Year of the American Space Station?

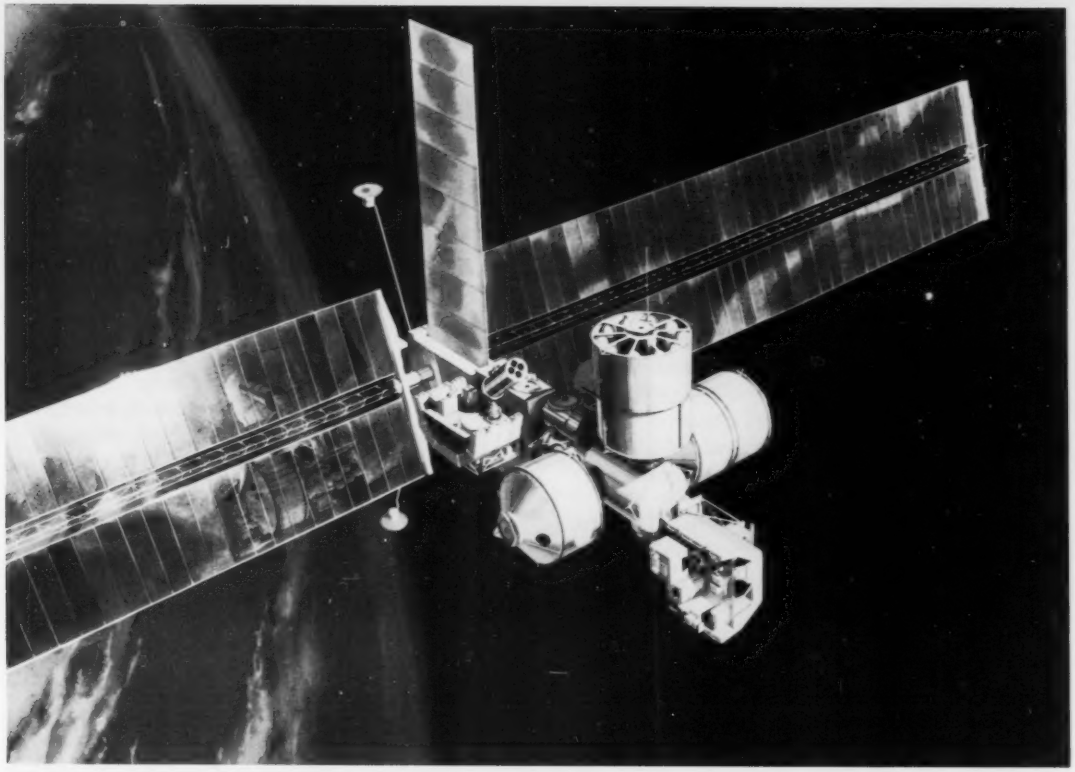
The United States has been characterized as a frontier nation—a country built upon a heritage of meeting new challenges. America's final frontier is space: the current challenge is full and routine utilization of this frontier for the benefit of all the people of our planet.

With the technology of the Space Shuttle, the United States is capable of routine access to space and back. A space station, designed as a permanent facility in orbit around the Earth capable of performing a variety of scientific and operational missions, will be the key that unlocks the second phase of the challenge—expansion of our knowledge and technology. The Space Shuttle provides us with the way to carry needed personnel and payloads for the final hurdle in this challenge—to operate in space routinely and permanently, a vital achievement we are striving to reach in the U.S. manned space program.

NASA has the capability to develop, construct and place in orbit a permanent space station by 1990. Skylab, launched May 14, 1973, was our nation's initial step toward a space station but this facility was not designed as a permanent presence. Its three-man crew rendezvoused and docked the Apollo command module with the Skylab space station on three different occasions with mission stays of 28, 58 and 84 days. Skylab demonstrated that men could function in space over extended periods of time. A permanent space station together with the Space Shuttle would dramatically improve our capabilities to operate in space for both civil and military purposes.

The Soviet Union has already launched a manned space station, Salyut 7, which orbits about 150 miles above the surface of the Earth.

NASA recently has formed a Space Station Task Force to prepare a program for a U.S. space station. The program will begin with mission analysis requirement studies submitted by several major aerospace companies. These studies are intended to define with specificity the various scientific, commercial and defense missions that could be conducted by a space station.



McDonnell Douglas Astronautics Co., reference concept for a space station under study contract to NASA's Marshall Space Flight Center, Huntsville, Ala. Shown is this concept taken to one of its potentials as a manned structure composed of communications antennae, two solar arrays, space radiator, rotating pallets capable of holding space science and applications payloads and an airlock joining two manned modules and a logistics module.

As of the present, just what a U.S. space station would look like is not yet certain. However, prior to formation of the Task Force and as part of NASA's advanced programs, several reference concepts for a space station were studied. One approach, under contract at Marshall Space Flight Center, Huntsville, Ala., is a "space platform concept"—a permanent facility designed to provide core services required of an orbiting spacecraft such as attitude control, power supply, communications, data management and thermal management. This space station concept would support science and applications experiments, either as a group or individually. Taken to its full potential, an air lock assembly could be added joining several manned modules.

A second space station approach that NASA has studied under contract to Johnson Space Center, Houston, begins as a manned facility designed to service satellites in orbit, assemble large space structures and stage launches into higher orbit as well as support science and applications experiments.

Basic elements for a U.S. space station emerged from these reference studies as well as from previous space station studies conducted by NASA:

(1) the design will be modular and expandable;
(2) it will be Shuttle launched and Shuttle tended;
(3) it will have a manned capability;
(4) it will have a national security dimension;
(5) it will have a re-boost capability enabling it to remain in orbit as a permanent structure;
(6) international participation in its development will be encouraged.

Currently there exists no precise cost data on the construction of a U.S. space station because no specific space station architecture or configuration has been decided upon. However, we believe that the initial phase of a small permanent facility could be placed in

low Earth orbit for approximately $3-5 billion over a period of several years.

The President in his Independence Day address (see page 13 of this issue) stated that the "United States must look aggressively to the future by demonstrating the potential of the Shuttle and establishing a more permanent presence in space."

And in his new national space policy, also issued July 4, 1982, the President reaffirmed NASA's commitment to space station technology by stating "the United States Government programs shall continue a balanced strategy of research, development, operations and exploration for science, applications and technology," listing among the objectives of these programs ". . . to explore the requirements, operational concepts and technology associated with permanent space facilities."

With the formation of the Space Station Task Force, NASA has begun to focus on this effort. I stated in a major space station address (see page 21 of this issue), "three factors make a space station a logical step in mankind's inevitable evolution into a space-faring civilation:

> it would build on the capability of the Shuttle to exploit the human presence in space effectively and economically;
>
> it would give us a place to do essential work in the areas of space science and exploration, technology development, space applications and national security;
>
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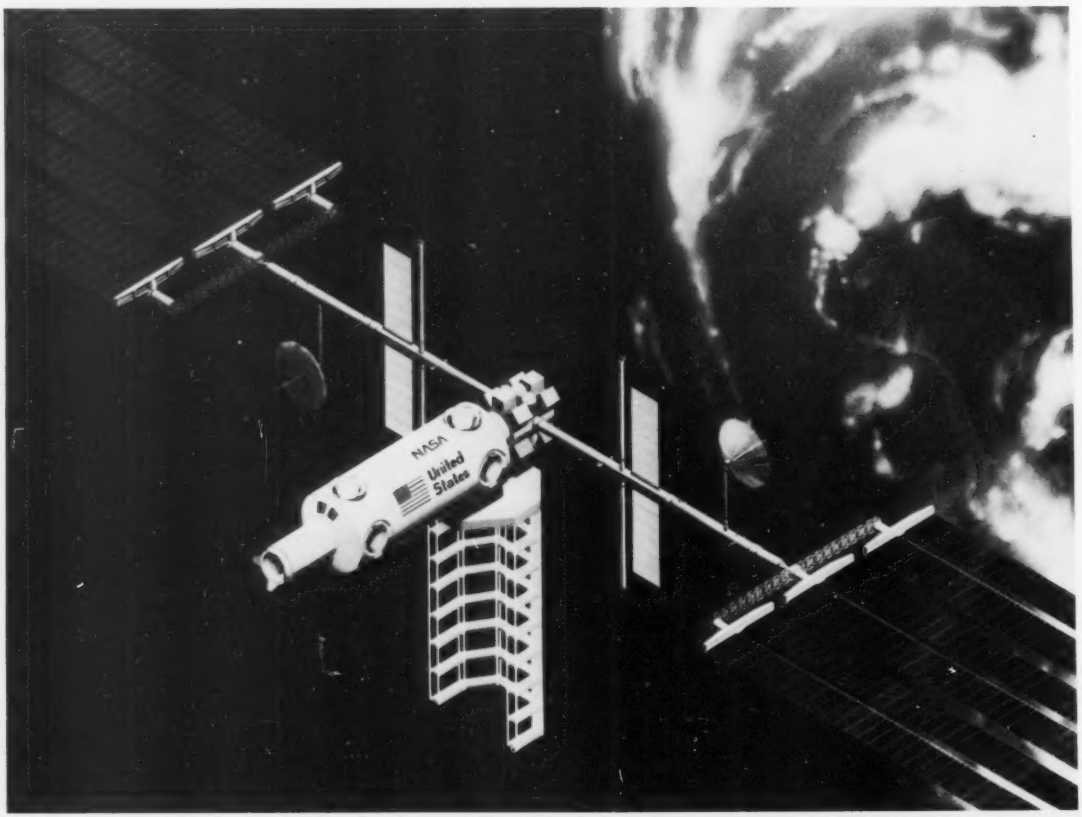


Space station reference concept under contract study by Grumman Aerospace Corp., and The Boeing Co., to NASA's Johnson Space Center, Houston. This concept, termed a "space operations center" is a manned space station. This particular space station is composed of an energy section comprised of solar array panels, radiators, and communications antennae, a data management command module (center) and a science module (top module). The platform extension hanging from the center module is an orbital transfer vehicle hangar.

Why the United States Needs a Space Station

Speech delivered by NASA Administrator James M. Beggs, Detroit Economic Club and Detroit Engineering Society, June 23, 1982

George Santayana once said: "Those who cannot remember the past are condemned to repeat it."

This is as true today as it has been throughout our history. Because we have learned from the past we have maintained the forward thrust of our young civilization. Indeed, young people are often the first to recognize this fact.

A few years ago a professor at the Wharton School of Finance tried an exercise to promote more crisp and concise expression among his students. He asked them to sum up in two words the outstanding characteristics of American society. What, in other words, has made us tick as a nation?

The best answer came from a young woman. Her two words were "we advance."

The key to that advancement, I believe, lies in the fact that we have a continuing urge to chart new paths and to explore the unknown. And that is the hallmark of any great nation.

That instinct drove Lewis and Clark to press across the uncharted continent. It guided Admirals Peary and Byrd to the icy wastes of the Poles. It drove Lindbergh alone non-stop across the Atlantic and sustained 12 Americans as they walked on the Moon.

The compulsion to know the unknown built our Nation. It impelled the pioneers to extend our frontiers across the wilderness to the Pacific. It was the compelling reason behind the "Yankee ingenuity" that increased our commerce and world trade. It moved our businessmen and our farmers to apply new technology to raise the productivity of our farms, factories and transportation systems. It challenged our leaders to develop dynamic new corporate, labor and governmental institutions. And it spurred the creativity of our scientists and engineers so that today, we lead, and are indeed, envied by the rest of the world in science and technology.

It is clear that if we ever lose this urge to know the unknown, we would no longer be a great nation. We must continue to advance the frontiers of knowledge. Nowhere is that challenge greater than in the continuing exploration of the last frontier—that of space.

Increasing our knowledge of the near-earth environment, the solar system and the universe will eventually help us to unlock the puzzle of why and how we came to be and what our future destiny might be. The spectacular photos of Saturn and the data returned from the remarkable journeys of the Voyager spacecraft have already taught us more about that planet than we knew from centuries of recorded observations. Moreover, in space there are real resources and opportunities for commercialization and industrialization. And space holds the promise of eventual human habitation on a permanent basis.

At NASA we are stretching our horizons to encompass all of these mighty challenges.

In the short lifetime of my agency, which stretches back only 24 years, we have come from an aeronautical base into a magnificent new era of space transportation with the Space Shuttle. This world's first reusable space vehicle, will give us routine, reliable and economical access to and from lower earth orbit and will provide the first step to similar access to geosynchronous orbit, lunar orbit and beyond, to the true exploration of the solar system itself. Its three test flights have proved that the concept is extremely sound. We are expecting to learn more about the Shuttle and its capabilities in its last test flight in just four days. And in November of this year it will begin operational service as the true workhorse of space transportation.

We are proud of the successful performance of this remarkable aerospacecraft and look forward to the time when it will demonstrate its versatility to the utmost—as a launch vehicle, as a spacecraft, as a base for scientific research, as a transport for commercial spacecraft, as a repair facility for satellites in trouble, and as the provider of routine roundtrip transportation to and from space.

Needless to say, we are also heartened by public backing for the Shuttle program. A recent Associated Press/NBC News poll indicated that 60 percent of the public believe the Shuttle is a good investment for America. Other polls tell us that 40 percent of the public think that the United States should be spending more on the space program. This is the greatest public support in the history of the agency—higher even than in the halcyon Apollo years, when we were very popular.

To me this support means two things. The first is that Americans are becoming increasingly aware of how crucial a vigorous high technology program is in keeping us ahead of our competitors in space. The second is that there is a growing realization that the national investment in the type of research and development that NASA does so well is more than worth it. The payoffs include new industries, new jobs, new products, new knowledge and a new spirit of national pride. Indeed, many have argued that the single transfer

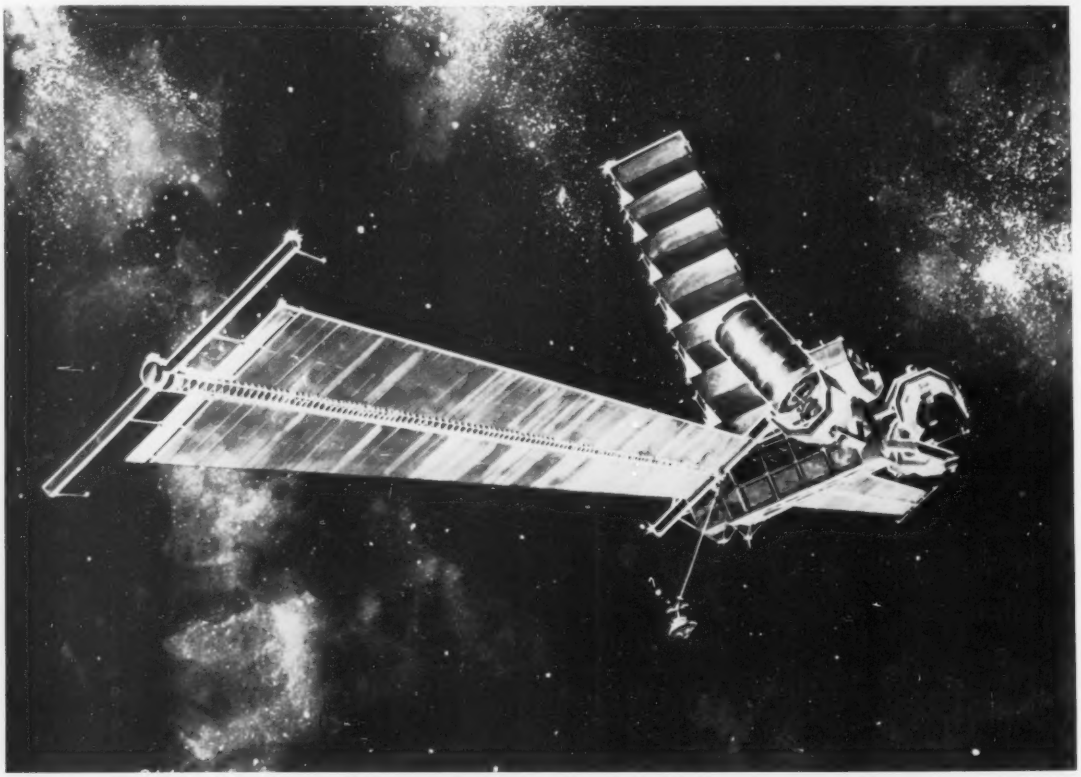
of NASA-developed communications satellite technology alone could suffice as payoff for our entire expenditures on the space program to date.

I am pleased that President Reagan and his Administration fully understand how important our work is to the nation. Even in these times of budget austerity, Administration support is strong. It resulted in a request for an eleven percent increase in real-year dollars over last year in NASA's Fiscal 1983 budget. This means that the Administration is committed to bringing the Shuttle to full operational capability and will support progress in all NASA major program areas.

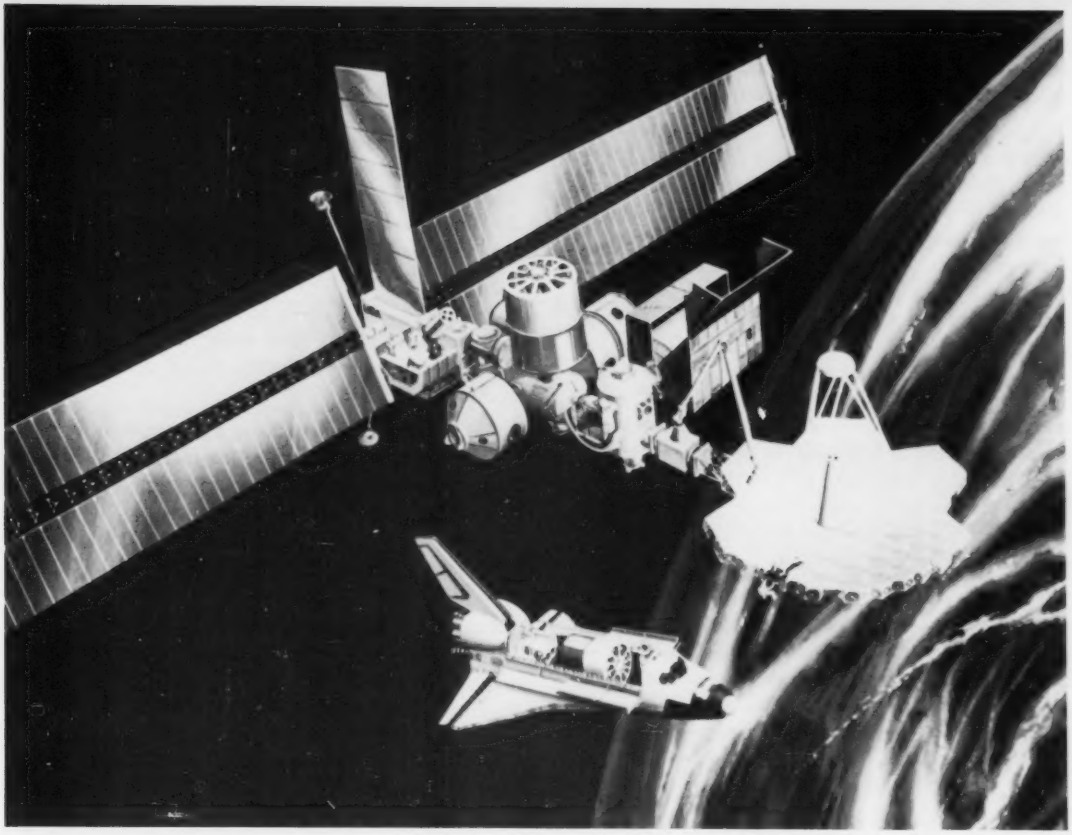
In a few years a fleet of at least four Shuttles will be flying routinely to and from space, ferrying into orbit commercial, scientific and national security payloads. The Shuttle has given us a head start in the commercialization, utilization and exploration of space. But as we look to the future, we must begin to secure that leadership in space through the end of the century and beyond. The way to do this is to set a fruitful new direction for the space program, one which would make the best use of the Shuttle's capabilities. And the time to do it is now.

I believe that our next logical step is to establish a permanent manned presence in low-Earth orbit. This can be done by developing a manned space station. At NASA we have begun to focus on that goal. We think that such a station could be built and placed in orbit by 1990. It would be small at first, assembled in orbit with modules carried to space by the Shuttle. Once there, the station would make a vital contribution to our nation's future, by opening new vistas of science and technology, new possibilities for commercial applications of space, and new opportunities to enhance economic security and the national defense.

To many, the idea of a space station may seem a bit far-fetched, an esoteric science fiction fantasy that could only be realized centuries from now. But they forget that once before the United States developed and launched a space station, although one not designed for



TRW reference concept for a space station studied under contract to NASA's Marshall Space Flight Center, Huntsville, Ala. Shown is TRW's unmanned space platform concept shown from an underside view. This particular space station is composed of communications antennae, two solar arrays, space radiator and several rotating pallets capable of holding space science and applications payloads. This platform concept taken to full development could include an airlock assembly joining several manned modules.



Reference concept for a space station that features a modular space platform of rotating pallets containing space science and applications payloads with airlocks joining three manned modules. At lower center, the Space Shuttle hovers near a large antennae platform.

a permanent presence in orbit. It was called Skylab and it was launched almost ten years ago, in May of 1973.

Skylab served as home for nine astronauts during its active life of 1½ years in orbit. On three separate occasions, men lived and worked in this U.S. space station for periods of 28, 58 and 84 days. Skylab not only demonstrated that humans could function comfortably and effectively in space for extended periods, but it showed how important man is to our activities in space. On several occasions astronauts had to perform critical repairs on the spacecraft, both internally and externally. Indeed, the Skylab program nearly failed on its launch day but a skilled flight crew was able to rig an emergency thermal protection system and then two astronauts went outside the spacecraft to release a stuck solar array. These repairs permitted the mission to continue as originally planned.

Skylab also demonstrated the utility of an orbiting scientific laboratory. Its eight different solar telescopes greatly increased our knowledge of the sun, the stars and the galaxies; its Earth-sensing instruments revealed data about our Earth otherwise unobtainable.

Now that we have the Space Shuttle, we owe it to the nation to make optimum use of this new capability of routine and reliable access to and from space. What better way to make full and complete use of the Shuttle than to develop a manned space station in orbit tended and supplied by the Columbia and her sister ships?

In fact, the Shuttle program originally was conceived to include a space station. More than a decade ago a total system was envisaged in which the Shuttle would transport payloads routinely to such a station. Today we see the station functioning in many roles. It would serve as a scientific laboratory, as a space operating facility for assembling, resupplying and servicing satellites, and for launching spacecraft to higher orbit. And, of course it would play a role in national defense.

No doubt the Australians will be glad to hear that this time the station would have a reboost capability and controlled deorbit mechanism to enable it to stay in space for as long as we want it there.

There is much to do and much to learn in space—much that we would like to do and would be able to do with a space station. With a permanent human presence in orbit, we will much more effectively support those instruments which will probe further and further in space in our quest to more thoroughly understand our universe. We would look down, and, through the technology of remote sensing, improve our understanding of our own Earth, the natural resources it possesses and the impact of man upon those resources. With a space station, we would find it easier and more economical to launch planetary probes to study the surface chemistry of Mars and the geology of Venus. This knowledge would give us a much better idea of how all the terrestrial planets evolved from the solar nebula so that we might more accurately chart the course of Earth's future evolution.

The space station would serve as the assembly point for manned or unmanned missions to Mars and for probes to the asteroids and comets, which scientists believe contain a chemical record of the evolutionary phases of the solar system. With the station, ultimately, we could send to the nearby planets unmanned probes which could be programmed to return samples of planetary surfaces. Analysis of these samples would help us better to understand why life evolved on Earth and probably nowhere else in the solar system.

There are exciting and important opportunities, too, in commercial applications research in a space station.

Commercial applications of space technology, such as materials processing development and communications satellites, hold promise of development into markets far beyond those we see today. And many will see their origins in a space station of the type we have in mind. The span of these commercial possibilities is limited only by the boundaries of our imagination. And these boundaries would be vastly expanded by the experience we will gain from early use of the space station.

The development of a space station would also open new opportunities for international cooperation in space. Indeed, a space station could be the logical catalyst for a great new international cooperative venture for the Free World. It could serve to focus the intense interest and capabilities in space that our allies in Europe and this continent as well as in Japan already have. And it could provide a mutually beneficial cooperative project to cement Free World ties.

We already have a long history of international cooperative ventures in space stemming from the 1958 National Aeronautics and Space Act, which created NASA. Already we have more than 1,000 agreements with over 100 nations covering the full range of cooperative activities. Among the most visible of these are the $100 million Canadian-built Remote Manipulator System, the essential remote arm of the Shuttle; and the $1 billion European-built Spacelab, an orbiting laboratory which will be launched next year in the Shuttle's cargo bay.

An international cooperative effort on a space station would continue to link other countries' space programs to the Shuttle, strengthening the overall space program of the United States.

But as you and I know, there are many who would decry a new program of expansion into space. They would argue that we cannot afford to apply our limited resources to such goals as space stations and the like. The problems we face on Earth, they say, must come first; and never mind the planets and the stars. They will always be there.

I would remind these nay-sayers of the lessons of history. Since 1957 when Sputnik first shocked the United States into a space program, we have not been alone in space. Today although we still lead the world in space technology, and the Shuttle gives us perhaps a decade of breathing space to maintain that leadership, we have been joined by many nations and we now face growing and serious competition in space.

That competition comes not only from our friends in Europe and Japan, but from the Soviet Union, which has repeatedly stated its intention to construct a permanently manned orbital facility.

Although many tend to debunk Soviet technology and accomplishments in space, the Russians already have demonstrated an impressive operational space station capability. Their Salyut 6, presently unmanned, was launched in 1977, and was home to five main crews and eleven visiting crews from Eastern Europe, Cuba and Vietnam. Indeed, the Vietnamese cosmonaut who flew aboard Salyut 6 has more flight time in space than our second Columbia crew—Joe Engle and Dick Truly—combined. Salyut was resupplied periodically by the unmanned Progress spacecraft, an impressive technological achievement. And its crews were busily engaged not only in military activities, but in such civil functions as remote sensing, materials processing, space biology and medicine, astronomy and astrophysics.

The Soviets recently launched Salyut 7, to replace Salyut 6. Salyut 7 is now occupied by cosmonauts and

has been reported to represent a larger, more sophisticated system that would move the Soviet Union another step forward in its quest for dominance in near-Earth space. It is imperative that the United States and the Free World meet that challenge effectively and soon.

To paraphrase Shakespeare, if "we do not take the current when it serves," we will "lose our ventures." I believe the current serves us well now. The door to space has been opened and it could no more be slammed shut than could the doors opened by Gutenberg's printing press, Galileo's telescope, Fulton's steam engine or the Wright Brothers first flight. And that door leads inevitably to the extension of the human environment into space.

Three factors make a space station a logical step in mankind's inevitable evolution into a space-faring civilization.

The first factor is that the station would build on the capability of the Shuttle to exploit the human presence in space effectively and economically. It would represent a major step towards the goal of true exploitation of the opportunities which space provides for improving our nation's position in the world and for improving the quality of life for all mankind.

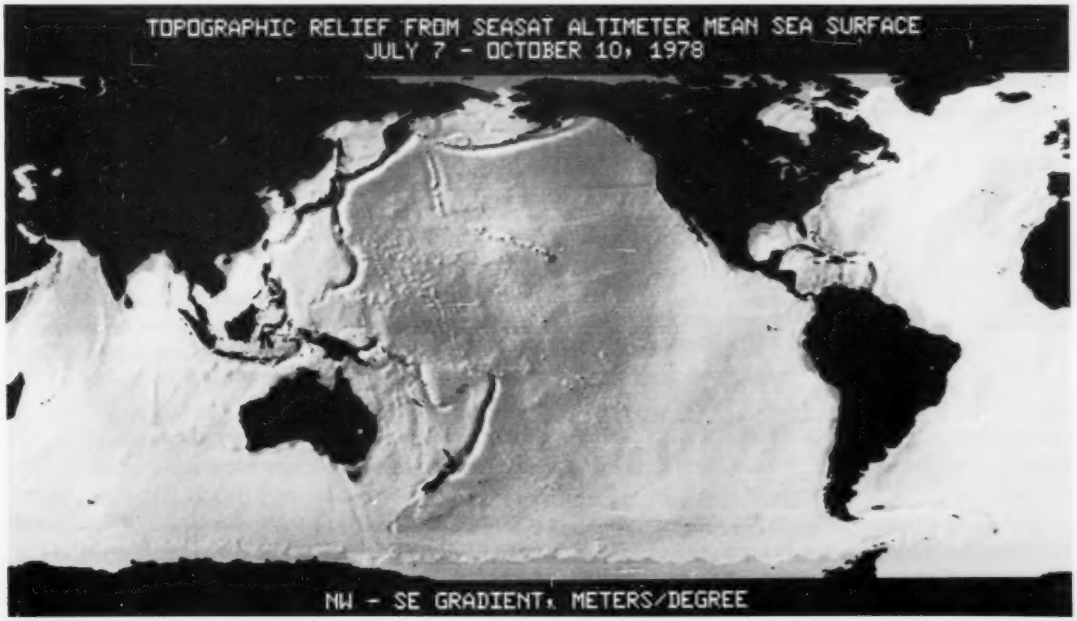
The second factor is utility. The space station would give us a place to do important, indeed, essential work in the areas of space science and exploration, technology development, space applications and national security. Space, we now know, is not just a place to visit. It is a place to work.

The third factor is one less tangible, but equally important. As a highly visible permanent United States presence in space, a space station would serve to enhance national pride at home and national prestige abroad. The Shuttle has done this for us today. The space station can do it for us tomorrow.

More than two hundred years ago, when our Nation was founded, we were weak in arms, poor in goods, but rich in spirit. Thomas Jefferson was able to say then after he drafted the Declaration of Independence that "we act not just for ourselves alone, but for the whole human race."

Today, the United States is strong in arms and rich in goods and still rich in spirit. We have built a magnificent new Space Transportation System. It holds unlimited opportunities for reinvigorating our economy, inspiring our youth, amassing new scientific knowledge, strengthening our defense and enhancing our national pride and prestige.

And we have an opportunity to act again, not just for ourselves, but for the whole human race.



100 Days of Data—Topographical map of the ocean produced from altimetry data from NASA's Seasat oceanographic satellite, launched in 1978. All the major differences of the world's ocean floor are reflected here as height differences on the sea surface. The map, comprised of 100 days of Seasat data, was produced by Jet Propulsion Laboratory oceanographer Dr. Michael Parke. Seasat was managed for NASA by JPL, Pasadena.

Four Moons of Uranus Measured For The First Time

Four of the five known moons of Uranus have been measured for the first time by University of Hawaii astronomers working under NASA grants. Uranus, nearly 3 billion kilometers (about 2 billion miles) from Earth, can only be seen with a telescope.

Sizes of the moons were determined from measurements of their infrared, or heat, radiation taken by NASA's Infrared Telescope Facility on Mauna Kea, Hawaii. This telescope, the most sensitive instrument in the world for measuring faint infrared sources, was constructed by NASA in part to provide support for spacecraft exploring the planets. The facility is operated by the University of Hawaii under contract to NASA.

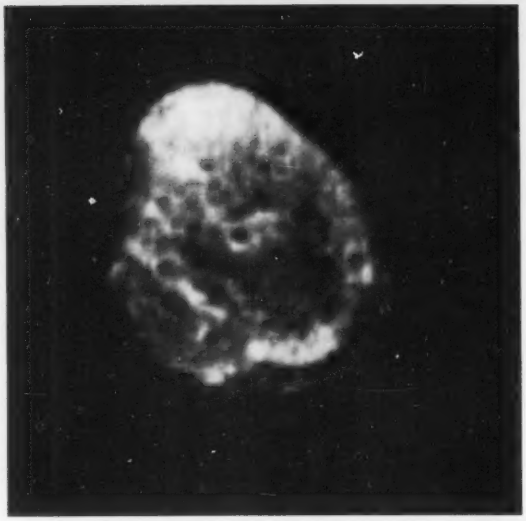
The new measurements reveal for the first time that these moons are large astronomical bodies, with diameters that range up to 1,690 km (about 1,100 mi.) for Oberon, the largest. (The moons of Uranus are all named for characters in Shakespeare's plays). Although smaller than Earth's moon, these objects are as large as any of the moons of Saturn, except for giant Titan, the only planetary satellite with a major atmosphere.

The new measurements also reveal that the moons of Uranus are darker than the bright icy Saturn moons investigated by Voyager. This result was a surprise to many scientists, who had suspected that the moons of Uranus might also be bright.

The presence of water ice on the Uranus moons had been discovered from astronomical observations carried out at Mauna Kea several years ago. The brightness and colors of the surfaces of the Uranus moons resemble closely those of Hyperion, one of the smaller moons of Saturn. It is believed that Hyperion's surface is composed of dirty ice—ice contaminated by darker material that may have formed at the time the planets were created.

In addition to the measurements of the moons of Uranus, the Hawaii researchers report that Triton, the largest moon of Neptune, and the planet Pluto, are both too small and cold for their heat radiation to be detected. From the weakness of these sources, they calculate that Triton must be smaller than Earth's Moon.

Dr. Dale R. Cruikshank, who has been studying Pluto and Triton for many years and was the discoverer of methane ice on the surfaces of both objects comments that these new results effectively eliminate the possibility that Triton is a giant moon, perhaps even the largest moon in the solar system. He says that both Triton and Pluto appear to be cold, icy objects of sublunar size.



Voyager 2 closeup view of Saturn's satellite Hyperion taken from a distance of about 500,000 kilometers (300,000 miles).

"Based on our current knowledge, they may be physically very similar to each other." There has been speculation in the past that Pluto might be an escaped moon of Neptune.

NASA's Voyager 2 spacecraft is now headed for Uranus following its successful flyby of Saturn 10 months ago; scheduled arrival at the distant planet is 1986.

Pioneers May Find Tenth Planet, Dark Star Or Black Hole

NASA's two Pioneer spacecraft, the most distant manmade objects in the solar system, may be able to detect a 10th planet out beyond Neptune and Pluto—or alternatively a dark star companion to the sun at perhaps 50 billion miles beyond Pluto.

The Pioneers have unique advantages for such a search, and persistent irregularities in the orbits of Uranus and Neptune strongly suggest that some kind of mystery object is really there—far beyond the outermost planet. (Because Pluto's orbit is greatly elongated, Pluto and Neptune take turns being the outermost planet with Pluto currently inside Neptune's orbit for the next 17 years.)

Pioneer 10 is now between the orbits of Uranus and Neptune and will be beyond all the planets in July

1983. Pioneer 11 is between the orbits of Saturn and Uranus.

Primary mission of the Pioneer spacecraft, which are managed by NASA's Ames Research Center, Mountain View, Calif., was flybys of the planet Jupiter. Pioneer 10 was launched in March 1972 and made its closest approach to Jupiter in December 1973; Pioneer 11 was launched in April 1973 and made its closest approach to Jupiter in December 1974.

The discovery in 1978 of a satellite of Pluto (since named Charon) reduces the calculated mass of the Pluto-Charon system to only one fifth the mass of the Earth's moon, and gives Pluto a diameter of 1,400 kilometers (1,500 miles). This is far too small mass to account for the unexplained tiny but regular shifts in the orbits of Neptune and Uranus. These orbital changes had been attributed to the pull of Pluto's gravity on the two planets.

A large dark-star type object (perhaps the size of the sun) and perhaps 50 billion miles beyond the outermost planet could produce the orbit shifts measured for Neptune and Uranus. This distance from the sun is a common one for dark stellar companions of visible stars.

A black hole, perhaps 10 times the sun's mass and twice as far out (100 billion miles beyond Neptune) also could account for the measured orbit shifts.

Either of these two types of objects would produce a general tidal effect in the solar system (an equal gravitational pull) on all the outer planets.

On the other hand, the pull of an undiscovered planet-sized object at perhaps 5 billion miles beyond Pluto and Neptune would also be consistent with orbit discrepancies for Neptune and Uranus. But these would be "local effects," and gravitational pull would vary markedly with planetary positions.

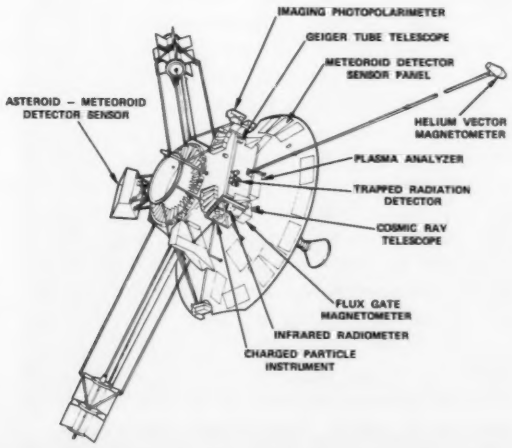


Diagram of NASA's Pioneer 11 spacecraft illustrating the various experiments carried aboard.

Since Pioneers 10 and 11 are on opposite sides of the solar system, one spacecraft would feel the pull of a "small and close" planet-size object far more than the other would. A larger, more distant body would pull on both spacecraft almost equally. Therefore, measurements of the solar system escape trajectories of the two spacecraft over periods of several years could be used to find out whether the Pioneers were being attracted by a relatively close planet versus a more distant dark star or black hole. Further observations would allow estimates of size and distance of such a planet as well as its direction. Calculations for this would be based on changes with location in space of the gravity field created by such an outside-the-known-solar-system body.

If the Uranus-Neptune orbit changes turned out to be due to a dark companion star or black hole, presence of such a large body could be verified, and a line through the sun and solar system could be drawn, which would also pass through the large "mystery body." However, it would not be possible to say from Pioneer data which of two sides of the solar system the body was on. Other types of measurement aimed at locating such a big object might soon be developed, once its presence was known.

While almost any dark celestial object is a possibility, Dr. John Anderson of NASA's Jet Propulsion Laboratory, Pasadena, Calif., Pioneer celestial mechanics experimenter, suggests that perhaps a dark stellar companion to the sun might be the most likely explanation. A 10th planet should be at least 5 billion miles beyond Neptune, unless it were completely out of the pattern of spacing (distances from the sun) for the other solar system planets (Bode's law). At this distance to produce the measured effects on Uranus and Neptune, it would have to be another giant planet, as large as Uranus (diameter, 47,300 km or 29,400 mi.) or Neptune (distance, 43,130 km or 26,800 mi.). If a 10th planet were still farther out, it would have to be even larger, on the scale of enormous Jupiter. Such a large body should be easily visible by telescope, and would have been discovered already. However, if the surface of such a giant planet (of either size) were very dark (unreflective) or far out of the plane containing the other planets, it might be hard to detect visually, and still be undiscovered.

Black holes, so far, are somewhat exotic objects, and only one black hole has been tentatively identified,

while dark stellar companions to stars like our sun appear to be relatively common.

"There is a whole class of objects ranging between a planet and a dark star. It could be any of these, and we are keeping an open mind," says Anderson. "We know there is a source of systematic variations in the orbits of the two outer planets.

"Work demonstrating these orbit variations has been done largely at the U.S. Naval Observatory, the Massachusetts Institute of Technology and NASA's Jet Propulsion Laboratory."

These Pioneer measurements should be much more effective than continuing measurements of outer planet orbits, since at the least 30 to 50 years of observations would be required, and probably several complete orbits. Pluto requires 249 years to complete an orbit, Neptune, 165 years, and Uranus, 84 years. All these are time periods so lengthy that they provide difficulties for practical observations. Several years of Pioneer measurements should provide essentially the same information.

The Pioneers have a further advantage as they are stabilized by their five rpm spin, rather than by the orbit-changing push of thruster systems. This means their precisely-known trajectories are shaped almost entirely by natural forces, and have been for many years.

Anderson believes measurements of the Pioneer orbits could detect a gravity force from outside the solar system as minute as one trillionth kilometer per second per second, or even one ten trillionth (Earth's gravity, at the surface, its equal to one hundredth km per second per second).

Measurements of Pioneer's position are made by two-way Doppler. A two-way radio signal is sent to the spacecraft at a known frequency. Changes in frequency of the returning signal due to the "Doppler effect" give changes in spacecraft velocity away from Earth to a fraction of a millimeter per second. Plotted continuously, these velocity changes give the exact spacecraft trajectory relative to the known exact locations of the Sun and planets. Unexpected velocity changes suggest the presence of another body.

Celestial mechanics methods (like those just described) have been used to find other outer planets. Differences between the real orbit of Uranus and its calculated orbit led to finding Neptune in the 19th century. Percival Lowell and William Pickering used Uranus-Neptune data to compute a hypothetical orbit for Pluto, although Clyde Tombaugh actually found Pluto in 1930 through a painstaking search of thousands of star photos.

"Slippery" Wings Smooth Way for Business Plane Fuel Savings

An aerodynamics advancement once thought to be impractical for powered aircraft may be practical after all, according to evidence gathered by a research team at NASA's Langley Research Center.

The smooth and aerodynamically clean lines of many airplanes developed since World War II may offer previously unrecognized advantages in performance and fuel efficiency that many older aircraft, with their protruding rivets and surface imperfections, cannot easily match.

The advantage results from a phenomenon called laminar flow. An airplane which achieves laminar flow can slip through the air with less effort, which can either increase speed or save fuel.

Airflow close to the surface of a wing or other smooth object is called laminar when its layers are thin and uniform and slide easily over each other, delaying the onset of drag-producing air turbulence.

Considered an intriguing opportunity as a result of wind tunnel and flight tests in the 1930s and 1940s, natural laminar flow proved to be extremely difficult to achieve on conventional riveted aluminum airplane designs. After several attempts by powered airplane manufacturers to capitalize on laminar flow, interest faded.

Unpowered sailplanes, however, had been exhibiting natural laminar flow at cruise speeds approaching that of powered light planes for some time. Sailplanes slice through the air efficiently because their shapes are aerodynamically good, and because they are made with plastic composite skins of fiberglass or kevlar which can eliminate waviness, rough body joints and other obstructions which destroy laminar flow.

Researchers at Langley recently predicted that modern construction techniques, developed since early NACA (National Advisory Committee on Aeronautics, predecessor to NASA) tests, now allow full-sized wings to be built that approach the smoothness of highly accurate wind tunnel scale models and flight test wings that demonstrated laminar flow 40 to 50 years ago. In the past several months, flight tests have been conducted which substantiated these predictions.

"I think many people will be surprised at our findings," said Dr. Bruce Holmes, of Langley's Subsonic Aerodynamics Branch and one of several researchers on the project. "While Langley had a clean-looking, full-size lightweight airplane made of fiberglass in the 9-by-18-meter (30-by-60-foot) tunnel last year, several of us thought it a good opportunity to check for

laminar flow. We put chemicals on all the wing surfaces, allowing us to visually determine the extent of laminar flow. The flow proved to be laminar on the lifting surfaces studied in the tunnel.

"That's when we took it a step further and tested eight actual flying aircraft, ranging in size from small two-place, propeller-driven, home-built airplanes up to a twin-engine business jet. All were aerodynamically efficient aircraft, and the flight tests proved that a significant part of their efficiency was due to the achievement of laminar flow, reducing drag by an estimated 25 percent in some cases," said Holmes.

Making use of construction methods developed since the 1950s, these airplanes have either bonded wing skins made of aluminum, integrally stiffened milled skins of aluminum or skins made of composites. Beneath the skins, wing substructures can vary greatly and represent another important area of advancement.

As a result, wing construction techniques have changed enough since the early wind tunnel work to allow modern wings on general aviation airplanes to achieve laminar flow.

Applications could go beyond the smallest of airplanes to business transports and commuter airliners, provided some crucial operational problems can be solved. For example, small amounts of ice buildup could cause large increases in drag on laminar flow wings.

More pervasive is the possible disturbance of the airflow by insects. "Wherever insects hit and stick, they may interfere with the smoothness of the boundary layer of air. What you want to do is to keep ice and insects

The black painted wing on this airplane allows researchers to visualize chemicals applied to measure natural laminar flow and its effects on airplane performance. The Bellanca Skyrocket II is constructed of fiberglass composite materials, providing an aerodynamically smooth surface. The chemical pattern shows laminar flow extending from the leading edge for about the first 50 percent of the wing's surface. Capable of speeds in excess of 300 miles per hour, the Skyrocket, a prototype business plane, is shown in test flight over the James River in eastern Virginia.

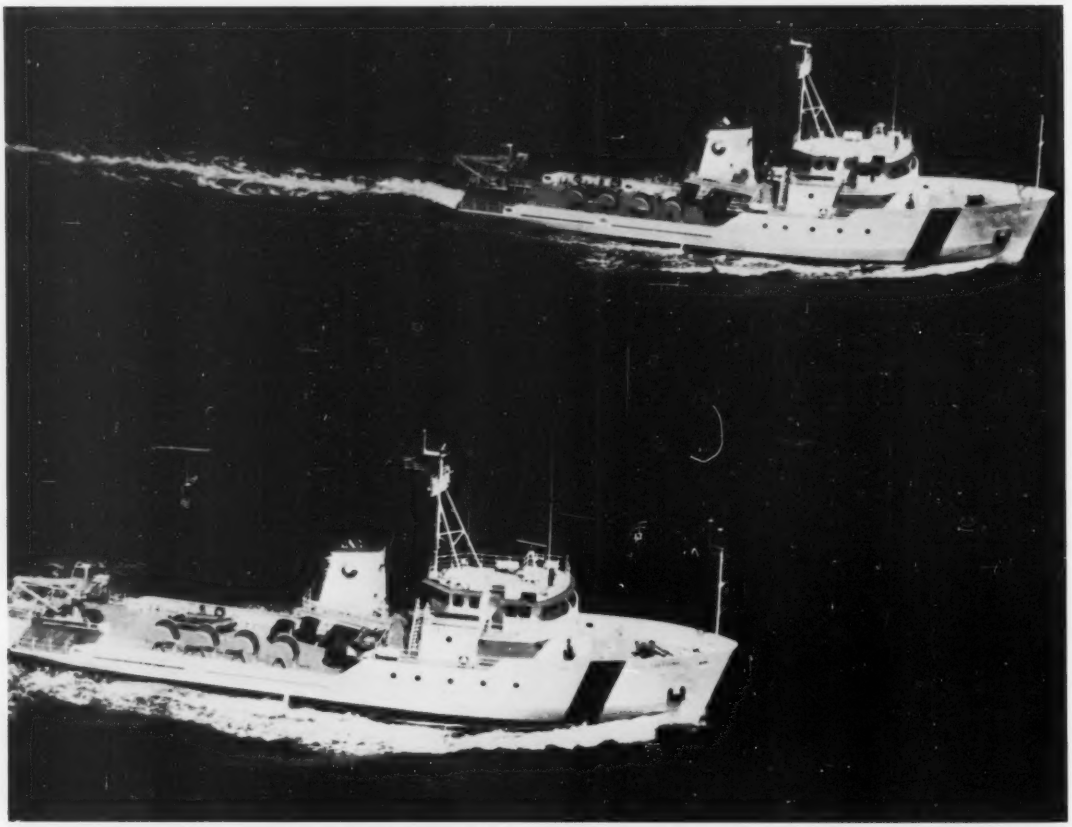
from sticking in the first place," Holmes says. Rain can temporarily do the same thing, as proven in flight and in wind tunnels. Tests are planned during the next year to evaluate concepts intended to eliminate ice and insect-sticking problems on laminar flow wings.

The additional effort to keep the wing and other lifting surfaces clean should be worthwhile. The payoff in fuel efficiency promises to be high. About half of the total drag on an airplane at cruise speeds is caused by friction between the air and the airplane skin surface. Explains Holmes, "That friction can be very low with laminar flow. However, if the flow is turbulent, that friction can be as much as seven or eight times greater."

Taking full advantage of maximum laminar flow will probably require new airplane designs, according to Holmes, because the same slippery qualities that can make wings aerodynamically efficient can be applied to the fuselages of certain designs as well.

Booster Hardware Set for Reuse on STS-5

Whatever happened to the reusable solid rocket boosters that helped lift the Space Shuttle from its launch pad on the first, second and third Shuttle flights? According to NASA's Vince Caruso of the Marshall Space Flight Center, in Huntsville, Ala., all six of the boosters are in various stages of refurbishment and are almost ready to be used again. Becausc refurbishment processing times differ for the various components of



NASA's Navy—Solid rocket booster retrieval ships, the UTC Freedom (foreground) and the UTC Liberty. Each vessel has a displacement of 955 metric tons (1,052 tons) and is equipped with sophisticated communications and navigation systems. The ships retrieve the frustrums and empty casings of the boosters along with the parachutes that have lowered them into the Atlantic approximately 6 minutes 54 seconds after liftoff of the Space Shuttle.

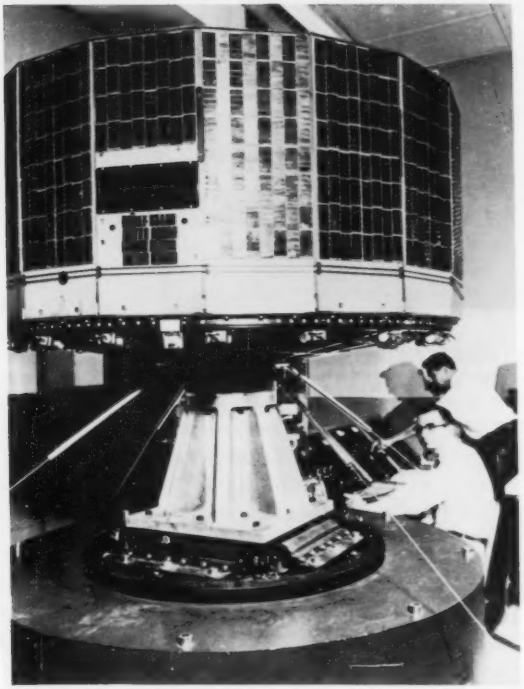
the boosters, some parts will be reused earlier than others.

The first pieces of booster hardware to demonstrate their reusable characteristics will be the parachutes used on the first Shuttle mission. The chutes have been cleaned, checked for any damage and repacked. They are slated for use again on the boosters that will help launch the shuttle on its fifth flight in November.

"Other booster components from STS-1 will be used on successive Shuttle flights," said Caruso who heads the production management and planning office for Marshall's Solid Rocket Booster Project. "The forward skirts and frustums of those boosters will go on STS-6, the aft skirts on STS-7 and the motor segments will fly on STS-8," he said. "Reuse of the boosters from flights two and three will follow the same pattern: the parachutes from STS-2 will fly again on STS-6, and so on."

Currently some hardware is sent back to the manufacturers to have the work done, but as the Shuttle becomes operational the majority of the work will be done at NASA's Kennedy Space Center, Fla., by United Space Boosters Inc., under the direction of Marshall's resident office located there. The solid motor cases, however, will continue to be returned to the manufacturer to be refilled with solid propellant.

The parachute systems are expected to be reused up to 10 times and the rest of the booster systems about 20 times.



Billion Mile Space Traveler—First TIROS weather satellite undergoing vibration testing at RCA Astro-Electronics, Princeton, N.J., before launch in April 1960. The satellite transmitted the first weather pictures ever returned from space. Under NASA's direction, RCA built 27 succeeding spacecraft in the series. In 22 years, TIROS (Television Infrared Observation Satellite) satellites have travelled more than nine billion miles and accumulated more than 67 years of useful life in orbit.

Finalists Chosen in Second Shuttle Student Involvement Project

Twenty finalists have been selected in the second national Shuttle Student Involvement Project, a joint venture of NASA and the National Science Teachers Association. Finalists for this competition were chosen from 196 semifinal entries based on individual scientific or engineering merit for potential assignment on future Space Shuttle flights.

Three student winners from the first national competition have had their experiments flown aboard the Space Shuttle: **Shuttle Flights 3,** March 22-30, 1982, "**Insects in Flight Motion Study,**" developed by **Todd Nelson**, Adams, Minn.; **Shuttle Flight 4**, June 27-July 4, 1982, "**Effects of Diet, Exercise and Zero Gravity on Lipoprotein Profiles**," developed by **Amy Kusske,** Long Beach, Calif., and "**Effects of Space Travel on Levels of Trivalent Chromium in the Body**," developed by **Karla Hauersperger**, Charlotte, N.C. These latter two experiments were medical in nature and required no hardware preparation.

The objective of the national Shuttle Student Involvement Project is to stimulate the study of science and engineering in grades 9 through 12 through a competition to develop experiments suitable for flight aboard the Space Shuttle. NASA pairs each student winner with a corporate sponsor and a NASA scientist or engineer to work with the student to determine the feasibility of developing the proposal into an actual experiment for flight. For those proposals determined to be feasible, a tentative development schedule is established. For those proposals determined not to be feasible, NASA attempts to assign the student to work with a principal investigator as part of an existing research team on a project in the student's field of interest.

Shuttle Complexity—View of the Space Shuttle cockpit shows some of the 1,800 toggle switches, pushbuttons, rotary switches, circuit breakers and other controls needed to fly the spacecraft. Under a study contract with NASA's Johnson Space Center in Houston, Boeing Aerospace Company engineers are designing new multifunction display and control systems which could replace many of these switches. Multifunction systems will help astronauts reduce the training time needed to master this complex assortment of controls.

Interdisciplinary teams of teachers, scientists and engineers reviewed more than 2,800 proposals submitted to 10 regional offices and selected semifinalists. Regional conferences for the semifinalists were held this spring at various NASA field centers.

Semifinalists' proposals were then judged by a national team which selected the finalists. Panelists on the judging team included representatives from the American Association for the Advancement of Science, Educational Resources Information Center, NASA, National Institutes of Health, National Science Foundation, National Science Teachers Association, Uniformed Services University of the Health Sciences, and several universities and consulting firms.

The 20 national winners and their teacher-advisors will attend a special Space Shuttle conference in August at NASA's Kennedy Space Center, Fla. At the conference the participants will receive briefings on Shuttle integration procedures, as well as tour the space center's facilities and view launch preparations for the fifth flight of the Space Shuttle Columbia, scheduled for November.

Most student experiments will be placed in storage lockers in the mid-deck section of the Shuttle orbiter. The mid-deck placement will allow easy astronaut access to the student experiments. As much as one hour of an astronaut's time during the flight may be allocated to work on the project.

Assisted by a sponsor and/or a NASA consultant, the student will analyze the data returned from the experiment and prepare a final report. All scientific data from the student experiments will be in the public domain and made available from the National Space Science Data Center at NASA's Goddard Space Flight Center, Greenbelt, Md.

A third Shuttle Student Involvement Project will open in September with regional conferences to be held in March 1983 with student winners being selected in May 1983. Information on entry procedures can be obtained by writing to the National Science Teachers Association, 1742 Connecticut Avenue, N.W., Washington, D.C. 20008.

The 20 student winners and experiments of the second national Shuttle Student Involvement Project are:

Sara H. Abozeid, Madison, Wisc., "**Testing Chemotaxis in Lumbricus Terrestris in the Absence of Gravity**." The purpose of this experiment is to determine the effects of carbon dioxide-oxygen gradient on chemotaxis in earthworms in the absence of gravity. The objective of the experiment is to see what causes worms to move up and down in the soil.

William S. Akmentins, Appleton, Wisc., "**Test of an Electrostatic Confinement in Space**." This experiment will determine whether an object can successfully be confined to a certain area using electricity in zero gravity, and if so, how much voltage does it take to keep the object in that area.

Sean M. Amberg, Seward, Neb., "**Statoliths in Corn Root Caps**." The effect of weightlessness on the formation of statoliths (gravity sensing organs) in plants will be tested by exposing plants with capped and uncapped roots to spaceflight. The root caps of the flight and control plants will be examined post-flight by electron microscope for statolith changes.

Lloyd Bruce, St. Louis, Mo., "**Effects of Weightlessness on Grain Formation and Strength in Metal**." This experiment will heat a titanium alloy filament to near the melting point and observe the effect that microgravity has on crystal reorganization.

S. Richard Cavoli, Marlboro, N.Y., "**Utilizing a Semi-Permeable Membrane to Direct Crystal Growth in Zero Gravity**." This experiment will attempt to grow fine, rod-shaped lead iodide crystals in zero gravity. Such crystals have application to develop image intensifying screens to be used as detectors of gamma and X-rays.

Steven D. Chang, Tustin, Calif., "**Time Dilations Due to Motion and Gravity**." The purpose of this experiment is to confirm quantitatively the simultaneous effects due to both Einstein's General and Special Relativity theories by comparing atomic clocks—one to be flown on the Shuttle and the other to remain on Earth.

Todd J. Egan, San Jose, Calif., "**Cocoon-Spinning Behavior of Silkworms**." Earthbound experiments have already indicated that silkworms, in spinning their cocoons, employ gravity as an environmental clue. This experiment will observe the effects a zero gravity environment will have on silkworms spinning cocoons in the Space Shuttle.

Andrew I. Fras, Binghamton, N.Y., "**Effects of Weightlessness in Space Flight on the Healing of Bone**." This experiment was designed to study the effects of space on changes on bone growth and repair.

Jeff B. Fuchs, Livonia, Mich., "**Atmosphere Pollutant Location and Concentration Determination Using Spectroscopy**." This experiment is designed to determine the locations and relative concentrations of certain atmospheric pollutants above selected sections of the Earth's surface through the use of spectroscopy—the study of the dispersed light from an object.

Edward W. Gulley, Winston-Salem, N.C., "**Observation of Various Gravity Induced Phenomena of Oat Coleoptiles in a Zero Gravity Environment**." Corn and oat coleoptiles will be positioned in space, with half oriented perpendicular to the others. They will be preserved in space with a fixative and examined post-flight for changes in callose formation and the distribution pattern of calcium ions and amyloplasts.

Douglas D. Hensley, Parkville, Mo., "**Effects of Deuterium Oxide on Plant Growth in a Zero-Gravity Environment**." The objective of this experiment is to explain the mechanism involved in the inhibitary effect of heavy water on deuterium oxide ($2H_2O$) on plant growth. It will determine if growth inhibition is due to impaired RNA synthesis on retardation of osmosis due to the greater mass of the $2H_2O$.

William D. Loftis, Jr., Scott Depot, W. Va., "**Monitoring the Effects of Simulated Gravity on Plants**." The object of this experiment is to see whether centrifugal force, as a gravity substitute, affects the generation and growth of bean and mustard plants at the

1g, ½g simulated gravity levels and at the zero gravity level.

Timothy D. Maclay, Springfield, Pa., "**Quantitative Confirmation of Einstein's Theories of General and Special Relativity**." The purpose of this experiment is to confirm quantitatively the simultaneous effects due to both Einstein's General and Special Relativity theories by comparing atomic clocks—one to be flown on the Shuttle and the other to remain on Earth.

Shawn P. Murphy, Newbury, Ohio, "**Purification and Growth of Single Crystal Gallium by the Float Zone Technique in a Zero Gravity Environment.**" For this experiment a single crystal of Gallium doped with Thallium will be grown in space and compared to a crystal grown in an identical manner on Earth. In the absence of gravity, a more uniform distribution of the Thallium and a more perfect Gallium crystal should result.

Tracy L. Peters, Walnut Creek, Calif., "**Zero Gravity Growth of Ice Crystals from Supercooled Water with Relation to Temperature**." This experiment will observe the formation of ice crystals at various supercooled temperatures below zero degrees centigrade in a gravity free environment. Absence of gravity will allow for a better understanding of the relationship between temperature and crystal geometry by eliminating faults.

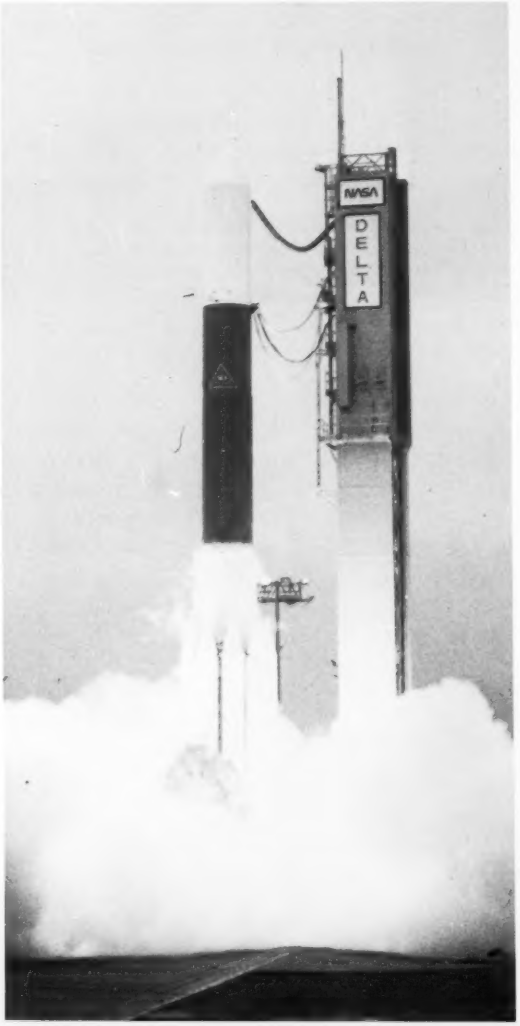
Gregory S. Peterson, Brigham City, Utah, "**Investigation of Arc and Ion Behavior in Microgravity**." This experiment is designed to study arc behavior in microgravity. The diffusion and turbulent mixing of gaseous ions, and the determination of minimum energy paths for successive arc discharges will be determined by use of the arc source called a Jacob's ladder.

Dan M. Poskevich, Waverly, Tenn., "**Comparison of Honeycomb Structures Built by Apis Millefera**." A premature colony of bees will be flown aboard the Shuttle to examine the effect of weightlessness on honeycomb construction.

Scott M. Tyner, LaGrangeville, N.Y., "**Effects of Heat, Light, and Zero Gravity on the Tunneling Habits of Earthworms**." This experiment will examine the tunneling habits of 10 earthworms flown aboard the Shuttle with the behavior of 10 worms in a control experiment on Earth.

Chia-Lien Wang, Waco, Texas, "**Measurement of Auxin Levels and Starch Grains in Plant Roots**." Bean plants will be grown and then frozen in space. The plant roots will be analyzed post-flight for auxin location and concentration and correlation with statholith location and the cells.

Timothy R. Young, Madison, Wisc., "**Effects of Microgravity on Red Blood Cell Mass in Horizontally Oriented Species Versus Vertically Oriented Species**." This experiment will investigate the process that stimulates a decrease in red blood cell mass of goldfish in a weightless environment.



NASA's July Launch—Landsat D, on liftoff July 16 from Western Space and Missile Center, Lompoc, Calif. The NASA earth resources applications satellite was carried to orbit by a Delta expendable launch vehicle.

Patents for Inventions from NASA Research

The office of General Counsel, NASA Headquarters, announces that the following U.S. patents have been issued by the U.S. Patent and Trademark Office to NASA for inventions resulting from NASA research. Inquiries concerning them should be directed to the attention of the NASA Patent Counsel of the indicated installation.

Inventor(s) & Employer	Title	Patent No.	Installation
William E. Miller, Arden Sher and Yuan H. Tsuo, College of William and Mary Williamsburg, Va.	Photocapacitive image converter	4,331,873	LaRC
Tage O. Anderson, Caltech/JPL	Control means for a solid state crossbar switch	4,331,956	NRO/JPL
Jack S. Margolis, Caltech/JPL	Coherently pulsed laser source	4,332,441	NRO/JPL
Judd R. Wilkins and David C. Grana, NASA/LaRC	Apparatus and process for microbial detection and enumeration	4,335,206	LaRC
Robert C. Bill and James S. Sovey, NASA/LeRC	Thermal barrier coating system having improved adhesion	4,335,190	LeRC
Robert C. Bill and Donald W. Wisander, NASA/LeRC	Fully plasma-sprayed compliant backed ceramic turbine seal	4,336,276	LeRC
John C. Evans, Jr., An-ti Chai and Chandra P. Goradia, NASA/LeRC	High voltage V-groove solar cell	4,335,503	LeRC
William A. Brainard and Donald R. Wheeler, NASA/LeRC	Improved refractory coatings and method of producing the same	4,336,117	LeRC

Space Shuttle Launches for 1982

Orbiter	Launch Date	Launch Site	Payload
*Columbia (OV-102)	March 22	KSC	OSS-1
*Columbia (OV-102)	June 27	KSC	DOD 82-1
Columbia (OV-102)	November 11	KSC	SBS-B, Telesat-E

* Successful launch

Expendable Launches for 1982

Name	Launch Date	Vehicle	Range	Mission Remarks
*RCA-C[1]	January 15	Delta	ESMC	RCA communications. Reimbursable.
*Westar-IV	February 25	Delta	ESMC	Western Union communications. Reimbursable.
*Intelsat V-D	March 4	Atlas Centaur	ESMC	Intelsat communications. Reimbursable.
*Insat 1-A	April 10	Delta	ESMC	India communications. Reimbursable.
*Westar-V	June 8	Delta	ESMC	Western Union communications. Reimbursable.
*Landsat-D	July 16	Delta	WSMC	NASA earth resources applications.
Telesat-G (Anik-D1)	August 19	Delta	ESMC	Canada communications. Reimbursable.
Intelsat V-E	September 23	Atlas Centaur	ESMC	Intelsat communications. Reimbursable.
RCA-E	November 18	Delta	ESMC	RCA communications. Reimbursable.
Intelsat V-F	December	Atlas Centaur	ESMC	Intelsat communications. Reimbursable.

* Successful launch

Another Dividend from Air and Space

Research and development in aeronautics and space have provided numerous benefits for all Americans—and at a tiny percentage of the tax dollar. Here is an example:

Increased Safety and Comfort

NASA's Ames Research Center, Mountain View, Calif., developed a foam material designed to improve crash protection for airplane passengers. This "memory foam,"* used in padding aircraft seats, not only provides better impact protection but enhances passenger comfort. Body weight and pressure is distributed over the entire contact area, flowing to match the contour of the body pressing against it and returning to its original shape once the pressure is removed. As a shock absorber, a three-inch foam pad can absorb the impact of a 10-foot fall by an adult.

This material has become one of the most widely used spinoffs from NASA technology with seat cushion applications in furniture, transportation vehicles, athletic equipment as well as medical applications such as wheelchair padding, hand padding for burn patients, and mattresses for the bedridden. Shown are two of these applications. At bottom left is an orthopedic seat for those who spend long periods in wheelchairs, office chairs, auto or truck seats. This foam cushion distributes pressure evenly providing a custom fit for the individual back and encouraging spinal disc alignment. In the photo above, this foam spinoff material is used in the cushions of helicopters operated by the Huntington Beach Police Department for greater pilot comfort and less fatigue. Department officials have found the cushioning has enabled an increase in patrol flying time.

* NASA does not endorse commercial products developed as a result of its Technology Utilization or Patent Licensing Programs, but it does encourage the widest possible use of its technology.

NASA
National Aeronautics and Space Administration

*U.S. GOVERNMENT PRINTING OFFICE : 1982 0-361-565/502